

AMERICAN METEOROLOGICAL JOURNAL.

A Monthly Review of Meteorology, Medical Climatology, and Geography.

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THE AMERICAN METEOROLOGICAL JOURNAL.

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ORIGINAL ARTICLES.

INSTRUMENTS FOR MEASURING ATMOSPHERIC PRESSURE.

[Abstract of lectures given by the writer in 1884 to the Officers at the Signal Service School of Instruction at Fort Myer.]

The discovery that the atmosphere exerted a pressure, and that this pressure could be measured, dates back to the time of Galileo, Torricelli and Pascal. The pressure of the atmosphere is measured by the barometer. The simplest form of this instrument is obtained by filling a glass tube (sealed at one end) with pure mercury, and placing a finger over the open end; invert it and plunge this end of the tube, finger and all, into a cup containing mercury; then remove the finger, and if the observer is near the sea-level and the tube is about 33 or 34 inches in length, some of the mercury will flow out of the tube into the cup until the height of that in the tube is about 30 inches above the surface of that in the cup. If now the tube is clamped in a vertical position to a rigid support and a scale of inches is placed beside it, also vertical, with the lower end of the scale resting on the mercury in the cup, it will be observed that from day to day (or sometimes from hour to hour) the scale reading of the height of the mercury in the glass tube will vary considerably. This variation in height may amount to as much as a couple of inches in the course of a few days.

The study of atmospheric phenomena has shown that these

changes are accompanied or followed by certain kinds of weather, and with such regularity that the barometer has received the name of weather glass.

To study these relations of "barometer height" (as the reading of the scale is called) to the weather, it is desirable to make as accurate observations as possible, and with this end in view various forms of construction for barometers have been proposed. In order that the instrument may not be easily injured, the glass tube is usually surrounded by one of metal, and as this tube is parallel to the glass one, it can serve as a scale for reading the barometer height when the inches and fractions are marked on it. Then, too, that the instrument may be easily carried about, the cup at the bottom containing the mercury is so arranged that it can be screwed on to the lower end of the metal barometer tube. The instrument in this simple form is a cistern barometer with immovable bottom, and is much used at sea.

Having now an idea of the general construction of a barometer, let us consider some of the different forms of this instrument. If, instead of a cup or cistern of mercury at the bottom, the lower end of the barometer tube is bent into a syphon form, we should have a simple form of this instrument. This is called the syphon barometer, and was principally used as a portable instrument until quite recently. In the syphon barometer we measure the distance between the two mercury surfaces, *A* and *B*, near the ends of the tube. The most popular form of instrument, however, is the Fortin barometer. This is a cistern barometer in which the lower end of the scale terminates in a fixed ivory pencil (within the glass cistern), the lower point of which is at the zero of the scale. The lower part of the mercury cistern into which the barometer tube projects, is of leather, and is pressed upon from below by the end of a screw. This screw has a large milled head, which, when an observation is to be made, is turned between the thumb and finger, and raises the leather cistern and with it the mercury surface, until the latter comes in contact with the ivory point; then the height of the top of the mercury column in the tube is read off on the scale. There are numerous makers of this barometer, differing slightly from each

other. Baudin, of Paris, however, makes a Fortin barometer with a glass cistern, which screws on to a thread on the lower part of the main barometer frame, and is tolerably accurate and inexpensive, though fragile. This instrument is entirely of glass except the upper rim of the cistern, which is a metal screw, and a corresponding metal rim with a receiving screw on the lower end of the tube. A small hole on a screw thread admits the air to the cistern. In this case the ivory pencil is replaced by a glass one, and the scale divisions are ruled directly on the tube.

About 1830, Kupfer invented the Syphon-Cistern barometer, various forms of which are used very extensively in Europe under the names of Turrettini, Köppen-Fuess, etc., and a few of the pattern mentioned here have been brought to America. Many improvements have been made on the original design, and the best at present in use are those of the Wild pattern, manufactured by Fuess, of Berlin. These instruments are undoubtedly the best portable barometers yet constructed, as far as accuracy is concerned, but they have not been in use long enough to see if they remain unchanged for a considerable length of time. As the name suggests, the instrument is a combination of the Cistern and Syphon barometers, the attempt being made to bring into one instrument the good points of both forms.

The arrangement of the tubing is best realized if we imagine, a Syphon barometer with the shorter leg cut through at the beginning of the bend: the bent portion is then straightened out, both of the cut ends inserted in a closed cistern filled with mercury, the cistern being adjustable by means of a screw at the bottom as in the case of Fortin barometer. In making a reading the mercury in the short leg is brought up to a fixed index at the zero of the scale by means of the screw at the bottom of the cistern, and the height of the mercury in the long tube is then read off and gives directly the barometer reading. The construction is so complex that further details would require a diagram to assist in making it clear.

(Drawings of the instruments are to be found in the "*Mélanges Physiques et Chimiques*" [1st Feb. 1883] of the St. Petersburg

Academy Bulletin; in Hann's Instructions to observers; in Fuess's Catalogue, and occasionally in the advertising columns of the *Meteorologische Zeitschrift*. The Signal Service has half a dozen of these barometers at Washington.)

The vernier reads to $.05^{\text{mm}}$. ($.002$ inch) and the $.01^{\text{mm}}$ can be estimated. A great advantage of this instrument is that it admits of the determination of the amount of air in the imperfect vacuum above the long column, this being done by measuring the height of the barometer when the top is about four inches from the end of the tube, and then by means of the cistern screw, raising the mercury so that its surface is half an inch from the top of the tube, and then making another reading of both mercury surfaces. If any air is present it will be more compressed in the second case than in the first, and will consequently make the barometer height less at the second measurement than it was at the first. The relation of this difference to the space occupied by the air, in the two readings, allows the amount of air to be computed. This form of instrument will be little used in this country, however, because it would be so difficult to get repairs made on account of the peculiar construction.

In regard to the accuracy of the readings of the various forms of instruments it is difficult to give positive values, but the following will not be far from right. If two ordinary Fortin barometers (such as are used at the stations of the Signal Service) are compared, the readings may differ by $.010$ inch from one comparison to another. In other words, if we know the error of the barometer as compared with an accurate standard instrument, we can be pretty sure of obtaining the true atmospheric pressure to within 0.25^{mm} . by a single reading at any time. A Fortin barometer of the highest class will give single readings with an accuracy of perhaps 0.12^{mm} . A Wild-Fuess (syphon-cistern) barometer of the best construction will give single readings with an accuracy of 0.05^{mm} . or 0.07^{mm} . For the latter instrument, if a series of ten readings is made on two barometers and each difference is subtracted from the mean of the ten, the average deviation of the single readings from the mean should not be more than 0.03^{mm} . We have seen perhaps three or four

Fortin instruments that could be read as closely as the Wild-Fuess barometers, but the personal equation between two observers is undoubtedly less for the latter instrument.

In the transportation of a barometer, the rule is to screw up the screw at the bottom of the cistern until the tube is full of mercury (and until as much air as possible has been expelled from the cistern), and then after closing up the air-hole to the cistern, invert the whole barometer, and always carry its cistern uppermost. With the ordinary Fortin barometer care need only be exercised in inverting; but a barometer of any other construction must not be inverted, except by some one who thoroughly understands the instrument. The syphon-cistern barometer must be held so that the short tube will be *uppermost* during the inversion, otherwise there will, probably, some air enter the long tube from the cistern.

In transporting a barometer by hand it is safe enough to carry it in an inverted position with the air well expelled from the cistern. If sent by express, it is best to have the cistern emptied of mercury and to let the end of the filled tube have a short piece of rubber tubing drawn over it for half an inch, bending the latter over the end of the glass tube and tying the bent piece firmly against the part of the rubber tube that is slipped over the glass tube. The emptying and refilling the cistern at its destination ought not to cause any change in the barometer reading. This must be done, however, by some one familiar with the manipulation of instruments, and who understands the construction of barometers and the errors to which they are liable. If the instruments are to be transported by water, or any way in which the sender can fasten them to a wall support where they will not be moved until they reach their destination, the following plan has been found to work satisfactorily. Attach two straps, each a couple of feet in length, to the wall by putting a nail or screw through the middle of each strap. These must be placed, the one about two feet above and two feet to the right or left of the other, so that a line drawn connecting them would be inclined about 45° to the level of the floor. Place a pillow against the wall between the straps, and put the wooden

bóx containing the barometer (cistern up) against the pillow, putting one of the straps over each end and drawing them up so that the barometer box will press firmly against the pillow on one side and be held firmly by the straps on the other. The barometer will then be inclined at an angle of 45° when the boat is steady. This will be sufficient to break any jar the instrument may receive, and will also keep it from moving any, which is very desirable.

In selecting a place to mount a barometer, it is best to choose a room with a northern exposure, in order that the diurnal changes of temperature may be slight. If the barometer is to be fastened to a wall, choose one against which the sun does not strike directly; but care must be taken to secure a good light for reading the instrument. If possible, it is better to make a framework at a distance of several feet from any wall, fastening the barometer at top and bottom to two cross pieces of this framework, using a plumb line to get the vertical.

In reading the instrument, first read the thermometer attached to the barometer (reading it to tenths of a degree); then lower the mercury in the cistern until the surface is a little below the lower index (or setting point); then slowly raise the mercury by means of the screw at the bottom until the surface just touches the lower index or point; next tap the barometer gently, and if the mercury seems to fall away from the lower index, bring it up to it again by gently turning the cistern screw; next make the setting on the top of the mercury column in the long tube and read the scale by means of the vernier. It is usual to read the scale closer than the vernier reads by estimating the difference between the actual reading and the nearest vernier reading. In comparing different barometer readings it is always customary to reduce the actual reading to what it would have been if the temperature had been at freezing (32° F. or 0° C.) For making this reduction many different tables have been printed, those most widely used being "Guyot's Meteorological Tables," published by the Smithsonian Institution at Washington. In comparing barometers with different scales always reduce to the freezing point for the scale of each barometer, and

make the conversion from one scale to another after this reduction has been made.

All ordinary barometers must first be compared with a standard barometer before their results can be used, as they are never perfect in construction. A barometer of unusually good construction, in the filling of the tube of which great care has been taken, is selected as a standard and mounted permanently at some observatory of repute. This is adopted as a standard for the country or state, and barometers that are to be used in making meteorological observations in this neighborhood (this term may have a very extended application) are brought here to be compared with this standard; or else a barometer is carefully compared with the standard and then is carried around the country for comparison with those of observing stations. Either method gives us the correction to be applied to the reading of the stations barometer, to reduce it to the reading of the standard.

The question comes up, do these standards agree the world over, and are they not subject to change? Professor Wild, of St. Petersburg, has been active in trying to answer these questions and remedy the defects indicated by the answers, and we shall have occasion to refer to his work later; but the most complete summary of the comparisons that have been made between the various standards of Europe is that prepared by Prof. Neumayer, of Hamburg, in 1879. He brings all the comparisons he can find together, and compares them with a standard adopted by him by combining the best standards. He has arranged the various results according to the amounts of the deviation from the adopted true standard. Those deviating within the limits .00^{mm} and .10^{mm}, were Greenwich, Paris, St. Petersburg, Stockholm, Salzburg and Vienna; those within the limits, .10^{mm} and .25^{mm}, were Christiania, Dorpat, Kopenhagen (Meteor. Inst.), Upsala and Zurich; between .25^{mm} and .50^{mm}, were Brussels, Helsingfors, Kew, Kopenhagen (Ag. Acad.) and Utrecht; and those deviating .50^{mm} and over, were Hamburg, Kremsminster, Prague and Pulkowa.

Thus we see how the various standard barometers vary among

themselves. Some of these values are the mean result of several comparisons, and the single results vary considerably at different times. For instance, the values for Hamburg-Vienna were $+.52^{\text{mm}}$; $+.70^{\text{mm}}$; $+.61^{\text{mm}}$; also Hamburg-Paris, were $+.42^{\text{mm}}$; $+.60^{\text{mm}}$ and Hamburg-Christianiana were $+.68^{\text{mm}}$; $+.95^{\text{mm}}$. So we see that if a person compares a barometer with the standard at Hamburg and at Vienna, and the next year another person carries a different barometer to the two places, they will not get the same differences between the standards, and these differences of results may vary from a thousandth up to a hundredth of an inch. But the ordinary standard barometers do not remain constant from year to year, and it is to be doubted whether any one barometer of the ordinary construction has remained uniform during its use as a standard. We find that the following changes in some of the best known standards have taken place: The Vienna Standard "Pistor 279" was raised $+.27^{\text{mm}}$ in 1872. The Freenwich Standard had .007 inch added to its reading in 1867. The Kew Standard changed (lowered) about $.30^{\text{mm}}$ about 1875. The Christiania Standard has changed by a relatively large amount. The Paris observatory Standard has also evidently undergone some change within the past twenty years. The working Standard of the St. Petersburg observatory changed its reading by several thousandths of an inch in 1833, although it had a very constant correction for several years previous to this time.

The points that affect a barometer, and consequently enter into the determination of the air pressure, are the following:

1. Temperature of the mercury.
2. Temperature of the scale.
3. Variation of gravity.
4. Impurity of the mercury.
5. Inclination of the scale to the vertical.
6. Graduation of the scale.
7. Changes in the length of the scale due to elasticity.
8. Gas in the vacuum above the mercury column.
9. Capillarity.
10. Errors due to the method of reading the height of the mercury surfaces.

In order to find what limits of accuracy must be reached to keep these various sources of error within prescribed limits, we will assume that for a pressure of 760^{mm} we wish no error to exceed .01 of a millimeter, this being the accuracy to be arrived at for a true normal barometer. We will now take up each source of error separately. The numerical values here given are Wild's.

1. Effects of changes of temperature of the mercury. For an ordinary temperature of, say 20° (C.) the mean temperature of the mercury column, for its entire length, must be determined with an accuracy of $\pm .07^\circ$ (C.). For the cubic coefficient of expansion the uncertainty for 1° (C.) must not exceed $\pm .00000066$. The coefficient of expansion of mercury adopted, for the temperatures between 10°-30°, is .00018002.

2. Influence of temperatures on brass scale. At 20° (C.) the reading of the scale temperature must have an accuracy of $\pm 0.73^\circ$; and in the cubic expansion of the brass, which for a mean temperature of 20° (C.) is about .000018007 for 1°, the uncertainty in this coefficient must not exceed $\pm .00000066$.

3. The gravity correction. The latitude of 45° and sea level have been adopted as the place to which the observations are to be reduced as a mean point; and whenever the observation point is more than 8' (2 geographical miles) from the 45° latitude, or is more than 42 meters above the sea level, the gravity correction must be applied.

4. The impurity of the mercury. The specific gravity of pure mercury at 0° (C.) is 13.5959, the unit being distilled water at 4° (C.) and the mercury in the barometer must not differ from this by more than $\pm .00018$. But it is much easier to obtain pure mercury, than to determine the specific gravity of that not so pure and find it necessary to apply the correction for the impurity. Mercury of sufficient purity can be had by first washing commercial mercury in dilute acid, shaking the bottle containing the mixture frequently during several days. Then pour off the acid and wash the mercury with pure water, and pour it into a clean glass vessel containing some chloride of iron, which being removed, and the mercury being filtered, leaves it ready for dis-

tillation. This can be done by means of a Weinhold distilling apparatus, or Wright's modification of the Weinhold form.

5. Inclination of the scale. In mounting the graduated scale great care must be used to get it vertical, but a good plumb line suspended from a steady support will do to show verticality with sufficient accuracy.

6. Errors of scale graduation. The only way to find out this error is to compare the scale with a normal scale of known accuracy. The comparisons must be made, not only for the whole length of the scale, but also for a dozen points throughout the length. Much of the accuracy of the barometer depends upon the carefulness of scale graduation.

7. Elasticity of the scale. The scale having been compared with the normal scale in a horizontal position and then hung vertically suspended from its upper end, the length will be found to have increased, $.01^{\text{mm}}$, when the whole weight supported by the scale amounts to 0.8 kilograms for each square millimeter cross section.

8. Influence of gas in the vacuum chamber. In the filling of a barometer it is impossible to get an absolute vacuum, and the difficulty increases when the attempt is made to fill the complicated tube of a normal barometer. It is customary in the best normal barometers to fill the tubes as carefully as possible, and then determine the amount of gas in the vacuum by means of the Arago method, that is, measure the height of the mercury column when the mercury is low in the tube and the length of the vacuum chamber is considerable (several inches) and then raise the mercury in the tube until the vacuum is reduced to a fraction of an inch in length. The reading of the barometer in the two cases will give the change in the pressure of the gas in the vacuum chamber caused by confining it to narrower limits. For one of the normal barometers at the International Bureau of Weights and Measures at Sevres, Paris, the reading of the normal barometer must be corrected by $+.13^{\text{mm}}$ to allow for the pressure of gas in the vacuum tube. The St. Petersburg normal requires a correction of about $.06^{\text{mm}}$ for the same purpose. The amount of gas in the vacuum tube depends princi-

pally on the care in filling. The best method for accomplishing this, is the one used by Wild, at St. Petersburg, and also adopted at Sevres, Paris, viz.: In the purification of mercury by the Weinhold process, it is distilled directly into the barometer tube after the tube (and the system of tubes) has been exhausted of air as far as can be done by use of a mercurial air pump.

9. Errors of Capillarity. Very little reliance can be placed on capillary corrections for small tubes, and in order to reduce this capillary correction to less than $.01^{\text{mm}}$, the barometer tube must be at least $.24^{\text{mm}}$ (1 inch) in diameter, and just before each observation the mercury must be made to rise in the two legs of the tube.

10. Errors of the method of reading the height of the mercury column. In order to keep the error of reading down to the limit fixed upon ($.01^{\text{mm}}$) the utmost precautions must be taken in the whole detail of making the readings. Up to 1873 there had never been a barometer that had been read with this desired accuracy. 1. The readings must take place in the same way for both mercury surfaces, that is, both surfaces must be as nearly alike as possible, both as regards form and method of reading, and with any arrangement, such as the Fortin, where the top and bottom readings are made differently, the desired accuracy could not be attained. The modern method of bending the tube of a syphon barometer so that the lower mercury surface is directly beneath the upper one, gives two surfaces as nearly alike as can be obtained. 2. The mercury must be raised in both tubes just before the reading is made, and this is done by having another tube (of rubber) leading from the bend in the syphon to a small mercury reservoir that can be raised or lowered at will, thus changing the height of the mercury in the two legs of the syphon. 3. With the ordinary form of cathetometer for reading the height of the mercury, only the most skilful observing and careful adjustment could give the desired accuracy, because the reading microscopes must be at a little distance from the barometer tube on account of temperature changes due to heat from the body. So in all modern barometers the cathetometer scale is suspended close to the barometer tube, and two reading microscopes are mounted

on a vertical stand at a distance of several feet from the scale and barometer. When a reading is to be made, the cross hairs of the telescopes are set on the upper and lower mercury surfaces, and then the microscope stand is turned slightly around the vertical and the telescopes pointed on the scale and the divisions read off, the fractions of the divisions being read by means of micrometers on the microscopes. 4. Another important thing is, to be sure that the reading of the true mercury surface is obtained. In order to accomplish this, various forms of illumination have been proposed and a steady improvement has been made. At first a piece of white paper, or other light reflector, was put behind the barometer tube, and the dark mercury surface projected against this background was observed with considerable accuracy. In the Wild normal barometer there is a plate, which is half black and half white, behind the mercury column. For telescope reading the upper half is black and the lower half white, and the dividing line is brought just above the mercury surface, so that the top of it is projected against the white surface, the black surface being just above for contrast. For microscope reading the white and black surfaces are reversed in position. In the Fuess normal barometer of 1881, at the Normal Standards Office, Berlin, we find a different method of illumination by means of reflectors. Here the barometer is in a dark underground chamber, and gas illumination alone is used. The best method, however, is that proposed by Marek and used in reading one of the normal barometers at the International Bureau of Weights and Measures, at Sevres. At least as early as 1873, Wild used a method of making an accurate reading of the mercury height in the open tube, by causing a needle to descend the middle of it, until the point almost touched the mercury. We have recently seen a reference to this as Pernet's method. In this way a sharp image of this needle point will be seen in the mercury, and if a setting is made of the microscope cross wire on this reflected image, and then on the point of the needle itself, the mean of the two readings will give the height of the mercury surface with great accuracy. (Any one can perform this experiment by taking a thin glass bottle of an inch in

diameter and pouring a little clean mercury into it; then insert a needle from the top and place the eye on a level with the mercury surface. Both the needle and its reflected image can be seen with great distinctness.) This is not so easily done in the closed tube, but Marek has found and applied a method. By means of a collimating lens the image of cross wires is formed in the middle of the barometer tube just above the mercury surface. This image has its reflection in the mercury just as the needle had, so that when a reading of the cross wires is made by the microscope, and then the reflected image is read, the mean of the two gives the actual surface of the mercury. This is done for both mercury surfaces. The error of a reading is about $.0015^{\text{mm}}$ as found by Marek; this is far within the necessary limits, and the method is so simple that it will probably be used very extensively in the future. Thiesen has proposed another modification of this principle. He uses a wide barometer tube so that the observing mercury surface will be about 40^{mm} in diameter, and a pencil point or other sharply defined object is placed outside the tube, but near it, where the object can be observed directly and its image reflected in the mercury can also be observed. The graduations of the scale can be used as points of observation, and these graduations can be on the barometer tube, thus greatly simplifying the manipulation of the normal barometer.

Regnault's normal barometer at the College de France, Paris, was the first true normal, but it had claimed for it only an accuracy of $.10^{\text{mm}}$. (A description of this instrument is given in English, in Cooke's Chemical Physics.) The first one fully investigated for all its errors, is that which was constructed for Prof. Wild, at the Central Physical Observatory, St. Petersburg, and which he fully describes in his splendid memoir in the "*Repertorium für Meteorologie*," Vol. 3, 1874.

Wild had previously mounted a somewhat similar barometer at Berne, but it was probably not as thoroughly investigated as his later one.

Normal barometers, differing from Wild's principally as regards method of reading, have been established, within a few

years, at Berlin, Sevres (Paris) and Hamburg. Descriptions of most of these instruments have been published, but in not easily accessible volumes. All of these instruments with the exception of the Hamburg (Seewarte) Normal are combined manometer-barometer, thus making the construction more complex than need be.

The instruments consist of a Syphon barometer with bent tube, so that the two mercury surfaces fall in the same vertical. The diameter of the tube being about 25^{mm}. at the two chambers at the ends where the readings are made, but much narrower throughout the greater part of the length. The scale is separate from the cathetometer and is placed very close to the barometer tube. A small glass cistern filled with mercury is connected with the lower part of the barometer tube by means of rubber tubing, and the raising or lowering of this cistern causes a corresponding change in the mercury surfaces in the barometer tube.

The mercurial barometer is so easily broken and so very inconvenient to carry that it is frequently replaced, by what is called the aneroid barometer. This instrument is entirely of metal, and being so small that it can be carried in the pocket, has come into very general use, especially by travellers. For a house instrument where the object is not scientific accuracy, but merely to note when "the barometer goes up or down," it is far preferable to the mercurial, as it can be hung up anywhere, and is not easily broken.

The aneroid is a very delicate instrument, and being subject to sudden changes, can only be used with confidence when it can frequently be compared with a mercurial barometer. Before an aneroid can be used at all it must be carefully compared with a standard mercurial barometer at all of the various temperatures and pressures to which it may be subjected in its use. The effects of the changes of temperature are different for different instruments. Wild gives the following changes with time in the corrections of an aneroid by Goldschmid; April, 1869, correction = -15.13^{mm} ; December, 1873, correction = -27.16^{mm} . Another by the same maker changed its correction only 2.5^{mm} in three years.

A thoroughly investigated aneroid of the best construction can be relied on to within 2^{mm} only when frequently compared, and when kept in one position. In travelling, the readings of an aneroid may be considerably altered, and it is impossible to fix a limit to its inaccuracy. The instrument must always be gently tapped with the finger before a reading is made, and it is also necessary to observe the temperature just as for a mercurial barometer.

We will now consider the thermo-barometer. Water boils at 212° F. (100° C.) at 760^{mm} pressure of the atmosphere at sea level. At an elevation above the sea the water will boil at a lower temperature; this is due to the decrease in atmospheric pressure. The law of this change in temperature of steam, with the change in pressure, is known, and if the temperature of the boiling water is accurately measured the atmospheric pressure can be computed. Only the very best thermometer of special construction can be used in this work, for if we wish to determine the pressure within $\pm .1^{\text{mm}}$ the error of the temperature determination must not exceed $\pm .004^{\circ}$ (C.). This accuracy is scarcely attainable in an observatory with the best thermometer and the most complete apparatus, and no care that a traveller could bestow would give such an accuracy at points along a journey. The thermometer must be of the best construction, and its reading extend from a little above 100° (C.) to a point lower than the temperature of steam at the highest point where observations are to be made. The instrument must be very sensitive and the graduations of the scale must be to tenths of a degree, in order that the hundredths of a degree can be read with considerable certainty. The thermometer must be carefully compared with a normal thermometer and its errors be investigated with great care. When an observation is to be made, the thermometer is put into a tube-like apparatus, having some pure water in the lower part, and a spirit lamp is lighted and placed under it; the steam can escape through a hole in the tube. The thermometer must be so fixed that the bulb is just a little above the water, and so that the whole tube will be enveloped in the steam, except the upper part, which must be exposed

for making the reading. The water should boil for eight or ten minutes before reading. When the thermometer has not been heated up to the boiling point for several days, the first reading must not be used, but it should be allowed to cool and be brought up to the boiling point again, and after eight minutes' boiling the second time, the reading can be made, a magnifying lens being always used for this purpose. More will be said on this point in speaking of thermometry, under which head the subject properly comes. Before a thermo-barometer is put into practical use, the whole apparatus should be placed in a receiver with a good barometer, and air taken from the former by means of an air pump until the pressure is as low as that to be measured by the thermo-barometer afterwards. Then comparative readings must be made of the barometer and thermometer, and the absolute corrections of the thermo-barometer at the various air pressures determined therefrom.

It has long been considered desirable to record the readings of a barometer automatically, and many different forms of mechanical construction have come into use. These can be divided into the following classes: 1. The purely mechanical arrangement, which has a float in the open leg of the barometer, and the motions of this float are recorded. 2. The electrical method, in which a platinum wire is made to descend the open leg of the tube, and when this wire, which is a pole of a battery, reaches the mercury surface, a circuit is closed by having the other pole already touching the mercury. The varying distance the wire moves from a certain point in order to reach the mercury surface is measured, and this measurement gives the barometric curve. 3. The photographic method, by which the height of the mercury in the closed leg of the barometer is photographed continuously. 4. The balance barograph, in which the variation of weight of the mercury in the tube is measured when the latter projects into a cistern containing mercury, but is not in rigid contact with the vessel containing the mercury. The barometer tube is suspended from one end of the balance-arm and is counterpoised by a weight on the other end. Various forms of balance are used, even the spring scales.

There are, perhaps, twenty different constructions of barographs, but they nearly all belong to these four classes, although there have been other forms proposed but not used. These instruments are of various degrees of accuracy, perhaps the best one being the Sprung balance barograph with sliding weight, constructed by Fuess, of Berlin.* The mean deviation of a registration of this instrument from the direct observation on a good ordinary barometer is only $\pm .04\text{mm}$, which is about equal in accuracy to the direct comparison of two portable barometers of the highest degree of excellence.

Several other barographs are scarcely inferior in accuracy to the Sprung form, especially the Wild-Hassler (as used at St. Petersburg); and the Photographic is also good. Eylert has also succeeded in getting good results from the Fuess barographs of the Deutsche Seewarte model. Much depends on the method of reduction of the barogram, however; the very common method of interpolating the direct sheet readings when compared with a mercurial barometer is not sufficient. We have not space here, to give some of the methods in use, but will reserve this for a future communication.

The self-registering aneroid is much used in observatories as an alternative instrument, and its record is, perhaps, a little more accurate than the eye readings of an aneroid, but it can be used for scientific work only when its readings are compared at least tri-daily with a good mercurial barometer.

FRANK WALDO.

A NEW THERMOMETER EXPOSURE.

Readers of this JOURNAL will remember the extended discussion on the best method of determining the free air temperature. The conclusion arrived at was that on all accounts, accuracy of the results, ease of making the observation, rapidity of action, etc., the sling psychrometer was ahead of all other proposed methods. Dr. R. Assmann has recently published a new method of solving this problem, and it will be of interest to

*Diagrams of the Sprung Barograph are found in the Fuess Catalogue; *Öster. Zeits. f. Meteor.* 1891; *Bericht d. Berliner Aust.* 1879; *Zeit. f. Instrumentenkunde*, etc.

American readers to see this method. The paper was presented to the Royal German Scientific Academy at Berlin, November 17, 1887.

Dr. Assmann objects to the sling psychrometer because—

- 1st. It is not wholly free from radiation influences.
- 2nd. It is difficult to shield it from rain.
- 3rd. It passes through a considerable mass of air whose temperature and humidity differ in different parts.
- 4th. It is in danger of being broken.

The first objection is of no consequence, since it is very easy to sling where radiation influences have little or no effect, and, moreover, wherever these radiation influences do have effect it is also equally impossible to obtain absolute values by any system. Precisely the same is true of the second objection. It is just as easy to shield the sling psychrometer by an umbrella or other covering as any other apparatus.

Dr. A.'s third objection is very surprising, rather than a drawback; it is one of the principal advantages of the sling psychrometer, and superior to any other device yet proposed. As to the fourth objection, I can only give my own experience. I have carried a sling psychrometer thousands of miles in my pocket, have swung one tens of thousands of times both on the earth and in four balloon voyages, and have yet to break one in the open air. Ordinary care is all that is needed.

In this proposed new method, Dr. A. starts with the self-evident proposition that all ordinary methods yet proposed for ventilating the psychrometer are faulty, from the fact that the fan or other apparatus imparts its temperature to the air current blown upon the thermometer. He would, therefore, place the thermometers, a dry and a wet, with bulbs .18 inch diameter, inside of a polished nickel-plated tube, .40 inch diameter, and 2.60 inches long, open at the bottom. The upper part of these tubes to be connected together and to a rubber tube, which would permit sucking air by the thermometers at a velocity of from one to eight feet per second. The criterion of accuracy that Dr. A. would establish is, that both thermometers should give identical results in the shade and in full sunshine.

Dr. A. found only a very slight difference between the readings whether the current was one foot or four feet per second. He found the time required to obtain the lowest reading for the dry thermometer, 130-150 seconds, and for the wet, 120-130 seconds. When he used a black surface on the inclosing tube instead of a highly polished nickel surface, the difference was only 1.1° F., and with a clear glass tube it was only $.6^{\circ}$ F. These results are quite surprising, and seem to show constant errors as well as a probable irregularity in both the speed, constancy and uniformity of the air current impinging upon the bulbs.

The following are some of the more serious objections to this plan :

1st. The proximity (within .11 inch) of a surface having a constant temperature oftentimes 20° F. above the wet bulb.

2nd. The drawing in of air from right around the mouth of the tube, and which will always have the temperature of the tube and not of the air. It was proposed in this country not long ago to extend this idea somewhat, and to make the tube, if necessary, 100 feet long, in order to obtain the temperature of air within that distance by running the tube to any desired point. It is easy to see that the air will take on the temperature of the tube before it reaches the thermometer.

3rd. In the case of the wet bulb the air would strike the tip of the cylinder and take on its moisture before reaching the top of the bulb, and in consequence the ventilation for the whole bulb would be very imperfect.

4th. There would be great difficulty in keeping the outside tubes at a high or even at a moderate polish.

5th. It would be very inconvenient to expose the apparatus, especially in a balloon or on a journey.

6th. The time taken to obtain the lowest reading would render the apparatus unserviceable in a balloon voyage. The sling psychrometer may be instantly exposed, may be quickly placed in safety when in danger of striking the ground, and above all may be brought to its lowest reading in 15 seconds. When it is considered that at times the balloon passes through the air at

from five to ten feet per second, the latter desideratum will be seen of the greatest importance. It is very surprising that scientific balloon ascents should be planned in Europe at this time, having such really worthless appliances for taking temperature and moisture. In a recent balloon voyage the method adopted was to take a self-recording thermometer; the difference in temperature observed at the same level going up and coming down was nearly 20° . Surely in these days of precision such a record ought not to be. I am sure that with the sling psychrometer there is no difficulty, even in a rapidly ascending or descending balloon, in getting the temperature of both wet and dry within a single degree in passing the same stratum up and down. My experience in four balloon voyages has convinced me that the sling psychrometer is the instrument above all others for the balloon, and is most admirably adapted for all its needs. I found no difficulty at all in slinging it to the lowest reading, taking the barometer reading and the time all inside of a minute, again and again, averaging 45 observations to the hour of the temperature, humidity, pressure and time. The observations of temperature and humidity have plotted excellently in both the ascending and descending paths of the balloon. On one voyage the height attained was 16,000 feet.

It is much to be regretted that Dr. Assmann has not published a few comparisons between the sling and his proposed method, but we can but believe that if such comparisons had been properly conducted they would have been much to the detriment of the new plan. We can but conclude that for all purposes where accuracy is desired the sling psychrometer is the only reliable apparatus for obtaining temperature and humidity, and is entirely feasible for all places and circumstances, except for self-registering and self-recording thermometers at a fixed observatory.

December 27, 1887.

The ink had scarcely dried on this paper before there came to my hands a "farther investigation" by Professor Wild, published in *Repertorium für Meteorologie*, Band X, No. 10; and, as this is very interesting in some parts, it may be well to

remark on it at this point. Professor Wild now admits that the sling thermometer gives the correct temperature after sunset, though he has always insisted that it read about 1.4° C. too high in clear nights. He has now practically admitted all the points urged upon him except one, and to this he still clings tenaciously. He still thinks that his normal exposure—a tin or zinc screen inside of a much larger wooden shelter—gives, when ventilated, the true temperature.

It should be noted that none of the experiments as far north as St. Petersburg can give a satisfactory law for much lower latitudes. Also, the shelter needed for a fixed observatory is not one that proves correct *after* ventilation, but rather, on account of maximum and minimum thermometers, one that gives directly the free air temperature. At the outset it may be said that no structure, whether of wood or metal, or a combination of these, no matter how well ventilated, can possibly give the true temperature in sunshine, because under intense insolation it will become heated, and any ventilation will move the surrounding heated air to the thermometers.

Professor Wild has given a long series of comparisons between sling thermometers in the sun and various shades, between black, bright and gilded bulbs, under various conditions and in his normal shelter. It seems to one examining these results as though Professor Wild had too strong a desire to prove that his shelter was accurate. It is impossible, at this time and distance, to reconcile all the seeming discrepancies in the results. Some of these are doubtless due to an actual difference of temperature in the various positions of the instruments; others are due to changes in the conditions of the thermometers, or in their exposure. Fortunately there are given in the last paper comparisons between his gilded and bare bulbs, and these show, precisely as found in this country, that there is no appreciable difference between their indications. The experiments in this country have shown that if there be given the readings of black and bare bulbs, side by side, the true air temperature may be computed by the formula

$$t_a = t_b - .6(t_a - t_b),$$

in which — t_b = reading of the bare bulb, and t_s that of the blackened bulb. We may then apply this formula, without sensible error, to most of the observations of black and gilded bulbs published in Nos. 4 and 10 of Band X, *Repertorium f r Meteorologie*. The following table contains these comparisons:

Date.	Black and Gilded.		Normal.	Date.	Black and Gilded.		Normal.
1885.	Unv.	Ven.	Ven.	1885.	Unv.	Ven.	Ven.
	C.	C.	C.		C.	C.	C.
June 25.....	24.2	24.4°	24.7°	July 3.....	23.0°	21.8°	21.3
" 25.....	24.6	24.8	25.1	" 3.....	16.5	16.6	16.8
" 26.....	26.9	27.0	27.5	September 18.....	14.7	14.4	14.0
" 27.....	25.5	25.6	26.0	1886.			
" 30.....	19.1	19.4	19.6	July 16.....	32.8	32.0	31.6
" 30.....	22.4	22.6	23.0	" 16.....	30.8	30.9	31.6
July 1.....	25.1	24.6	25.5	August 18.....	19.2	19.2	19.3
" 1.....	27.5	27.5	27.8	" 18.....	18.8	18.9	19.3
" 1.....	28.1	28.6	29.7	" 21.....	19.6	19.8	20.0
				Mean.....	23.5	23.4	23.7

This table explains itself. The second and third columns are computed from black and gilded thermometer bulbs. In case the observations extended over many hours, they are grouped generally, according to the heat of the day.

As I pointed out some time ago, there seems to have been a singular change in either the thermometers or their exposure between July 1 and 3, 1885. While before July 3 the normal was always the higher, whether ventilated or not, yet after that date it was often lower. The mean of all shows the normal .2° to .3° too high. Professor Wild found, with three sides of the wooden hut double boarded, a temperature 2.5° C. too high, and it would seem that, with the south side doubled, the best ventilation will still give at times .5° and more too high in his normal shelter.

The whole discussion is now narrowed down a great deal, and we may hope soon that all will come to a substantial agreement. From the first, the question has been of far less importance than many others regarding the exposure of meteorological instruments. However, nothing but good can come from such extended discussions.

H. ALLEN HAZEN.

WASHINGTON, D. C., Jan. 9, 1888.

A THIRTY-DAY PERIOD OF THUNDER-STORMS, THE MOON,
AND THE WEATHER.

In former numbers of this JOURNAL are articles by the present writer, in which evidence was given of the existence of an approximately regular period of about thirty days' length in weather changes. In the June, 1885, JOURNAL, it was shown that there had been at Ann Arbor, during a part of 1884 and 1885, an approximately rhythmical oscillation in the temperature, of about thirty days' length. In a paper by the writer read before the American Association for the Advancement of Science, in September, 1885, it was shown that over the eastern half of the United States there had also been a similar oscillation in the pressure and rain-fall; and in the February, 1886, JOURNAL, it was shown that predictions based on this periodic oscillation during four months of 1885 had been 80 per cent. verified.

In light of these facts, it is interesting to find from the just issued *Extract No. 25 from the Annual Report of the Chief Signal Officer* for 1886, that Professor H. A. Hazen has discovered a period of about thirty days in the frequency of thunder-storms during the summer of 1884. A curve is given by Professor Hazen, which shows that the maximum frequency of thunder-storms over the northern United States, and the maximum departure above the normal temperatures, was reached about the twenty-third of each of the months June, July, and August; while the least frequency of thunder-storms, and the lowest temperature, were reached about the middle of each of the above months—though the period seems to have failed in September. When the summer was divided into periods of thirty days, and the thunder-storms added together into one period of thirty days, the regularity of the oscillation from a maximum to a minimum was still more marked. The average at the time of minimum was less than 300 thunder-storms per day, while the average at the time of maximum was over 600 per day. Professor Hazen traces this period out in connection with the phases of the moon. The synodic period of the moon is $29\frac{1}{2}$

days, and the close coincidence in length with a weather period of about thirty days, naturally suggests a deeper connection. Professor Hazen found that the maximum heat and the maximum number of thunder-storms during the summer of 1884 occurred about the time of new moon; but if we follow this thirty-day weather period into the winters of 1884-5, the new moon is found to occur much nearer the time of greatest cold; and in the summer of 1885 about half way between the times of greatest abnormal cold and abnormal warmth.

If any one will take the United States Signal Service *Weather Reviews* for the winters of 1886-7, and look at the charts on which are drawn curves showing the changes in pressure and temperature at a few stations in the United States, it will be seen from the curve for St. Paul that the pressure in that region was noticeably lower, and the temperature higher during the middle of each month than at its beginning and end, showing very clearly an oscillation of about thirty days. The same is not so noticeable in the Boston curve, but by slightly smoothing the irregularities out, it is readily shown to exist, and attracted the attention of the writer, who called attention to it in the *Boston Transcript* before the *Weather Reviews* appeared, which show the phenomena so well at St. Paul.

I.	II.	III.	IV.
1886.			
November.....	29.29		+4°
	.21	-.08	+2
	.25	+.04	+4
December.....	.37	+.12	-9
	.21	-.16	+3
1887.	.46	+.25	-2
January.....	.37	-.09	-9
	.11	-.26	-5
	.31	+.20	+9
February.....	.63	+.32	-0.3
	.34	-.29	+4
	.32	-.02	-6
March.....	.47	+.15	-4
	28.86	-.61	-1
	29.09	+ 23	-6

In the above table, column No. II shows the average press-

ure at the top of Blue Hill, for each decade from November to March ; column No. III shows how much the average of each decade differed from the one which preceded it ; and column IV shows how many degrees Fahrenheit the average temperature of each decade differed from the normal.

It is seen that the lowest pressure and the greatest minus departures occurred in the middle of each month ; while the greatest minus departures of the temperature occurred at the beginning and end of each month, and the greatest plus departures, with two exceptions, occurred in the middle of each month. When these are plotted in curves, the thirty-day oscillation is well marked, though the temperature and pressure curves oscillate in opposite directions, as is, always the case in the winter months.

At the time of these oscillations the new moon occurred between the time of greatest warmth and greatest cold, while in 1885 the full moon occurred in connection with this phase of the oscillation. Hence, in light of these facts, and in absence of any known physical fact, why the moon should have any influence on the weather, it would seem that the supposed connection was only a casual phenomenon ; though the existence of a thirty-day weather period, which occasionally becomes quite prominent, seems to the writer strongly substantiated by facts which as yet, however, remain empirical facts.

H. HELM CLAYTON.

CORRESPONDENCE.

LOCAL WEATHER PREDICTIONS.

To the Editors of the METEOROLOGICAL JOURNAL.

I dissent strongly from the method and conclusions of the anonymous article, by "Gan," on "Local Weather Predictions," in your December number. It seems to contain an unfriendly spirit of criticism, shown in the presentation of meaningless comparisons, from which it is concluded that "an ignoramus would get a better percentage than an able man," and that "the skill in prediction and the assistance acquired from

the daily weather maps are really hindrances" The object of the comparison seems to be to show up Mr. Clayton's work in a ridiculous light, making it appear to be no better than that of a child or of a totally ignorant person; but it is difficult to conceive that Gan himself is not aware that his method is utterly illogical and fallacious. A totally ignorant person could not know enough to choose from among the several verbal forms of prediction those particular forms which would lead him to the highest percentages of success. He would be as likely to say "decidedly lower" as "stationary" temperature, for he could not be expected to know that, according to definition, even in so changeable a climate as New England's, the temperature from day to day is generally "stationary"; he might persistently announce "rain" in a climatic area where rain is well known by every one else to be less frequent than fair weather; and in these cases his percentage of verification would be very low. If Gan would try the luck of all kinds of children and ignorant persons, including those who would be so unguided as to predict decidedly colder weather every day from April to August, and decidedly warmer weather every day from September to January, as well as those so slightly and knowingly ignorant as to predict only the commonest kinds of weather, then the average of all the results might be now fairly compared with the results of professional prediction: but such comparisons are not worth the trouble of making them. Gan's untiring devotion to work might be better applied in an investigation of the individual cases in which the Signal Service and Blue Hill predictions differ.

Gan says "there should be the fullest discussion, by those understanding the situation, as to what the public really desires" This is undoubtedly true. I would add, if I may be admitted to the discussion, that it is so true that, if an ignorant person were to publish in the papers an unchanging prediction of fair weather and stationary temperature, day after day, the editorial authorities would soon be warranted in discouraging him, for the public would, in a very short time, have quite enough of such work. It would be no justification for

him to appeal to his high percentages, for arbitrary percentages are not what the public really desires. The public prefers a sincere attempt to predict the different kinds of weather as they come along, even though the resulting percentage of verification falls below that gained by a skillfully ignorant person. It is, I believe, in obedience to this preference that the term "local rains" has been discouraged in the official forecasts; for we no longer see the attempts to hedge behind this vague expression, which at one time diminished the practical value of the Signal Service predictions, although it increased the arithmetical percentage of verification gained by some of the Signal Service predictors.

As far as I know, Mr. Clayton's predictions are the only ones in this country that have been made and published systematically and long enough to give basis for a fair comparison between work in a central office with all possible facilities, except actual sight of the weather, and work in a local office based on a general map and local observations. Time and expense, as well as accuracy, are factors in the comparison. The central office has fuller reports, charted on several sheets, and has also better opportunities for study of former records so fully represented in its archives, and for discussion of methods among its several experts. The local office has the advantage of a sight of the actual local weather up to the moment of prediction, but it has the disadvantages of an incomplete and relatively stale weather map, prepared by less expert hands than those employed in the central office, and its opportunities for study and discussion, even at the best, can hardly be considered equal to those enjoyed at Washington.

The net result of Mr. Clayton's work seems to me to be that it would be worth while for the Signal Service to try for a time the experiment of instituting a sub-office in that district where its percentage of verification is lowest, in order to discover if it would be advisable to change its general methods to more local ones. An essential point in the experiment would be the preparation, if not publication, of predictions for the district in question at both offices. I should be glad to see both predictions

published, if it were only to emphasize the fact that predictions are based largely upon unformulated judgment, and that they cannot, at present, always be regarded as scientifically authoritative.

W. M. DAVIS.

CAMBRIDGE, MASS., Jan. 8, 1888.

To the Editors of the METEOROLOGICAL JOURNAL:

In the last JOURNAL appeared an article on "Local Weather Predictions," in which prominent mention was made of the Blue Hill predictions. The author preferred to conceal his identity behind a *nom de plume*, but since I have excellent reasons for believing that it was written by one of the leading officials of the Signal Service, I think his views are worthy of attention.

His article, as I understand it, embodies three conclusions: 1st, the comparison between the Blue Hill predictions and those of the Signal Service are untrustworthy, because the latter have been made for a much larger area than the former, and it is unfair to verify them by the records of one station; 2d, the methods of verification used at Blue Hill are untrustworthy, since by such methods an ignoramus could gain as high a percentage of successful verification as is claimed for Blue Hill; 3d, better methods of verification are much to be desired.

With this last proposition, and this alone, I most heartily agree.

In regard to the first proposition, the writer who signs himself "Gan" was, perhaps, not aware that the Blue Hill predictions were made for southeastern New England; and since the Signal Service is now predicting for separated States, this area is as large as, or larger than, any predicted for by the Signal Service in this locality. In most of the New England States there is only one Signal Service station in the State. In Vermont there is only one; in New Hampshire, only one; in Massachusetts, only one (unless Nantucket or some of the flag display stations on the coast are counted); and in Rhode Island there is one. Hence I do not see how it is possible for the Signal Service to make official verifications for these States except by the records of these single stations. There are five Signal Ser-

vice stations in southeastern New England, but in order that the Blue Hill verifications might be comparable with those of the Signal Service it was thought best to use only one station, centrally located, for verifying the predictions. Otherwise the predictions would show a higher percentage of success than they do at present.

The Signal Service, when asked to make predictions for large cities, have, I think, always avoided it; but when any comparison between their predictions and local predictions are made, they reply that it is easier to make predictions for small areas than larger ones. In some respects this is true, but I think any one who tries it will find that when predicting from weather maps, with present facilities, it is, in most respects, much easier to predict for large areas than small ones. In summer, when an area of low pressure and showers is advancing across the Lake Region toward New England, it may be easy to foresee that there will be local rains in New England; but to foretell whether one of these showers will strike Boston is another and a more difficult undertaking. In the winter, when a general rain is approaching New England from the west, it may be easy to foresee that it will rain in New England; but to tell whether that rain will pass north, or south, or over Boston is more difficult. Moreover, it seems to me that the value of any predictions depends upon how often they are verified at any one point, for this is what the inhabitant of any place wants to know. For these reasons, it was thought best to verify the Blue Hill predictions by one station alone, although if verified for southeastern New England, they would have given a higher percentage of success.

In his second proposition "Gan" attempts to show that the methods used for verifying the Blue Hill predictions were untrustworthy, since a continuous prediction of one thing by a child would, according to these methods, have given a higher percentage of success.

In choosing our methods of verification it was necessary that we should be guided by what was already in use in our country. The Signal Service stated in the rules sent to voluntary observ-

ers for verifying the Signal Service predictions, that a day on which a measurable quantity of rain fell was to be considered foul and justify a rain prediction; while days on which no rain or only a trace of rain fell, were to be considered fair. I was told by one of the predicting officers that .01 inch of rain was called a measurable quantity in the official verifications. Accordingly these definitions of fair and foul were adopted in making the Blue Hill predictions.

I have frequently expressed my regrets that there were no better methods of verification than those now in use, since these entirely fail to show the superiority of the Blue Hill predictions over those of the Signal Office. To take one example: the Signal Service sometimes predict fair weather, followed by rain, when Blue Hill predicts rain, followed by fair weather. The weather proves to be as last predicted, yet, according to the present method, both are called verified. Hence, though I believe the method of verification given to voluntary observers by the Signal Service, and now used at Blue Hill, is a very poor one, still I am not disposed to believe that predictions made in accordance with, and verified by, this method are worse than could be obtained by predicting *fair* continuously.

In making his comparisons, tabulated in the last JOURNAL, "Gan" selected the driest months of 1887. During all except one of these months the rain-fall was decidedly below normal, and there was almost a drouth. It has become an adage that "all signs fail in dry weather." In such cases when areas of low pressure pass over, the clouds become dense and seem almost on the point of rain, but they as frequently pass away, and not a drop falls. In such cases a predictor must be guided somewhat by normal conditions, and he is likely to find at the end of the month that he has predicted rain oftener than it occurred. But even such predictions are certainly better than a prediction of *fair* all the time, for they indicate to the public the times when rain is most likely to occur, and the times when rain is scarcely at all likely to occur; and this must be of value even though rain is predicted too often, and at the end of the

month it is found that a uniform prediction of *fair* would have given a higher per cent.

Moreover, if "Gan" had made his comparisons for months in which the rain-fall was nearly normal, he would have obtained very different results from those he has published. The Blue Hill verifications were published in the Bulletin of the New England Meteorological Society for every month of the year 1887, instead of for the few months selected by "Gan"; and if those months are taken which "Gan" omitted, the following results are obtained:

COMPARISON OF PREDICTIONS BY MR. CLAYTON WITH PREDICTION OF
"FAIR" EVERY DAY.

	1887.					
	January.	February.	March.	April.	December.	Mean.
Mr. Clayton.....	81%	79	74	83	90	81
"Fair".....	61%	46	61	57	58	56

The same was true of the temperature predictions: "Gan" only selected those months, viz., the summer months, in which there were few marked temperature changes, and thus was enabled to show that a prediction of stationary temperature for every day would give a higher per cent. than Blue Hill. These temperature predictions are on a somewhat different basis from the regular predictions of the Signal Service, and hence cannot well be compared with them. The idea was only to predict when marked changes of temperature were expected to occur, and say nothing at other times. The predictions thus become somewhat analogous to the cold wave predictions of the Signal Service. During January and February, 1887, the Signal Service had six cold wave warnings for this vicinity justified; one warning failed to be justified; and there were five failures to predict. When these are verified and compared according to "Gan's" method, with a prediction of stationary temperature for every day of the month, the latter will give as high a per cent. of success as the former. Is it, then, to be concluded that the cold wave warnings were of no use whatever? I think not, for I think these warnings of great value to the public. The trouble, I think, is that there is something wrong with "Gan's" *methods*.

The weather predictions issued from Blue Hill have averaged from five to ten per cent. higher than the Signal Service predictions for this locality; but since the methods of comparison have been called in question, perhaps it will be allowable to adduce public opinion as evidence in the matter. Complimentary notices of the Blue Hill predictions have appeared in almost all of the Boston papers; and to prove that these are not mere empty compliments, the Associated Press in southeastern New England have been willing to pay something for the predictions, notwithstanding they have free predictions from Washington.

One reason why I believe a greater difference than is shown by the estimated percentage is felt to exist between the Blue Hill predictions and those of the Signal Service is that, though the predictions of each are based on telegraphic observations taken at 7 A. M. and published in the same afternoon papers, the Blue Hill predictions are made to begin *nine hours later* than those of the Signal Service, and reach the public many hours before they begin. The Signal Service predictions do not reach the general public until the time for which they are made to begin, and frequently when rain is predicted it is already raining when the "Indications" reach the public. In such cases the predictions, though verified, seem to me of no value.

I think enough has been said to indicate that the Blue Hill predictions are certainly not worse than nothing; and, moreover, that they are more appreciated than those of the Signal Service for this locality. Hence I feel warranted in believing, as Mr. Rotch has before asserted, that it is impossible for a general predictor to make better predictions than a local predictor with the same skill, even though the latter has very much less telegraphic data. At Blue Hill we obtain from the Boston Signal Office telegraphic reports twice a day from less than seventy stations. The Signal Office, for their predictions, use reports from nearly 150 stations, and each station telegraphs two or three times as many data to the central office as is sent out to the local offices of our large cities.

For maintaining all these stations and telegraphing the reports the Signal Service pays over \$500,000 annually, and besides,

according to the 1885 Chief Signal Officer's report, over \$50,000 was paid for clerks, messengers, etc., at the central office at Washington. The partial reports, such as are sent to the local offices and newspapers of our large cities, probably do not cost one-fifth of this amount; and I believe a large body of local predictors could be maintained for what is now paid to clerks at the central office at Washington. Hence I believe a greater efficiency at a very much less cost could be obtained by decentralizing our weather bureau. Yet I do not think the greatest efficiency could be obtained in this manner. It seems to me better to combine both methods; that is, to have scientific experts at Washington to study and predict the movements of areas of high and low pressure, and leave the local predictors to fill in the details of weather for their section. For the greatest efficiency, these local predictors should have reports from a net-work of secondary stations in their locality, such as those of our voluntary observers.

If our government needs to economize, I believe, for the reasons given above, that it would be much cheaper to have weather predictions made by local rather than a general weather bureau; but since economy ought not to be necessary, I think the last method suggested would greatly improve the efficiency of the weather service. Moreover, I do not think our weather bureau ought to be burdened by having also to perform military duties.

H. HELM CLAYTON.

BLUE HILL OBSERVATORY, January 15, 1888.

SELECTION.

TIERRA DEL FUEGO.

[CONCLUDED].

There seems to be no doubt that both of these contradictory stories are to some extent true, according to the part of the country which you may happen to visit. The fact is, the land is inhabited by two very distinct races of Indians; those who occupy the northern portions of the country being quite different in size, appearance, and manner of life from those who live

along the channels and among the islands of the southern extremity. Mr. Brydges, who, from his long residence among these peoples, probably knows more about them than any other living man, not only assures us that there are two tribes, separate and distinct, but explains that the difference is the result of the great difference in their modes of life and the circumstances to which they respectively have had to adapt themselves, according to the localities in which they lived. Those who dwell in the north he calls Onas; those in the south, Yahgans; and he obtained these names from the tribes themselves.

The Onas appear to be quite identical in customs, character, appearance, manner of living, and even in language, with the Tuehelche Indians of Patagonia. Like them they use bows and arrows in the chase after guanacos and for killing feathered game. They are very muscular people—large, active, and well formed. They speak of themselves as “footmen,” to distinguish them from the Yahgans, who spend their time in canoes or in fishing. The number of the Onas is now quite reduced. Fitzroy estimated them to be about 600 souls. An epidemic of measles, a year or two ago, was very fatal, and the entire tribe does not now number more than 500 persons. They principally occupy the pampa region, from Anegada Point on the north to Thetis Bay and Admiralty Sound on the south. They are nomadic, and wander from one part of the country to another, according to the season or the exigencies of the chase. They carry their tents with them, as these merely consist of a few poles, generally covered with guanaco skins, or sometimes thatched with rushes. Abandoned encampments are to be seen all over the country, where hillsides or valleys afford protection from the winds. The men do the hunting, while the women do the heavy work and carry the burdens. Besides their bows, the strings of which are made from the sinews of the guanaco, the men are equipped with quivers made of skin, which are always filled with a full complement of heavy arrows, pointed with a sharp stone or piece of glass. Mr. Popper, whose recent explorations in *Tierra del Fuego* I have already referred to, has, in a lecture just delivered before the Argentine Geographical Society, given us so

graphic a picture of the Onas Indians that I am induced to make a translation of it. He says:

The central portions of *Tierra del Fuego* are inhabited by a race of corpulent, strong, and muscular natives, whose height sometimes exceeds six feet. Their skin is of a clear, copper color, and is soft and oily to the touch. Their dark, lusterless, woolly hair falls in tufts around a large tonsure, cut close in the top of the head. The face is oval shaped, of an orthognate type, and exhibits a narrow forehead, adorned with frontal protuberances slightly accentuated. The forehead terminates in a pair of prominent and scarcely arched eyebrows, which give the eyes a deep and energetic expression. The cheek-bones are prominent; and the nose is convex and almost aquiline. The mouth is of medium size, with small teeth covered with a yellow enamel. There are a few hairs on the chin; and the ears, depressed and disjointed, complete a face which calls to mind the North American Indians rather than the *Tuehelches* on the other side of the straits. The head rests upon straight, strong, and broad shoulders, and a prominent, well-developed chest; whereas the breasts of the women are depressed, pendent, and flaccid, though I have seen some exceptions. The arms of the women are strong and round; those of the men are muscular. The bulky hands contain short fingers, which terminate in flat, square nails. The general gait of these Indians is heavy. The dimensions of the abdomen vary very much, according to the time at which he has taken his Fuegian meal. In the lower parts of the body nature has been less prodigal. The legs, although straight and strong, are not in proportion to the body; the calves are meager, terminating in ill-defined lines, and the feet are of moderate size. Notwithstanding the rough and severe climate which prevails, the inhabitants use no other clothing than a cloak or "poncho" of guanaco skins, and they generally live in tents, the sides of which are made of a couple of poles on the windy side, over which skins are stretched or grass is banked. The only decoration I observed on the women is a bracelet of perforated shells. It is quite impossible to distinguish the females from the males by their dress, though they exhibit but little modesty in exposing their persons. The Onas are extremely nimble. Being obliged to hunt the guanacos on foot, they acquire the habit of running with incredible swiftness. Through curiosity I measured the tracks left in the sand by an Indian who fled before us, and the length of each step was nearly two meters. The wounds which I have seen them inflict on themselves, and which perhaps are connected with some superstitious belief, denote strength of mind, and lead me to the conviction that these aborigines can, without much suffering, bear fatigue, cold, hunger, and every species of painful impression.

With regard to the intellectual faculties of the Onas, they cannot be:

much developed, if we may judge by the primitive implements they use in their every-day life. Their tools, for the most part, consist of pieces of iron, taken from some vessel cast on shore, wrapped up and tied to pieces of wood by leather thongs. For digging up the ground they use the shoulder-blade of the guanaco; and the only water-vessels they have are large marine shells, scallop or trumpet shaped. They have no canoes, nor do they devote themselves to fishing. They only pick up the fish cast on shore when the heavy tides run out. Some intellectual effort is remarked in the making of arrows and baskets. The former are beautifully finished and evenly pointed with sharpened stones or pieces of glass picked up on the shores. The baskets are made of rushes, which are so interwoven as to be at the same time strong and flexible. A cord made of guanaco sinew, placed across the opening of the basket, serves as a handle. To catch birds they use traps made of thin and flexible whale-bone, in the form of movable rings, which, being hidden in the grass, answer the same purpose as the well-known wooden trap for catching partridges and other game.

During the course of the expedition I tried to enter into friendly relations with the Onas whom I met, but, I am sorry to say, without any success. Instead of corresponding with our friendly relations and dispositions, they invariably showed an undisguised tendency to make war on us.

Other travelers confirm this warlike disposition of the Onas. On the approach of strangers to their shores they are inclined to be aggressive, and stories are told of their cruelty to sailors who have been shipwrecked on their coasts. The Argentine authorities and ships of war, owing to the want of welcome with which they have been received, have already had a number of rencounters with them, in some of which the Indians were shot down with Remingtons. I doubt not, however, these unfortunate affairs have been owing more to the timidity of the Argentines, who, in their awkward attempts to open communication with the natives, have precipitated hostilities in the apprehension that they was about to be attacked or led into ambush.

The Yahgans, who inhabit the southern portions of Tierra del Fuego, are altogether a different people from the Onas. Perhaps with some reason they have been considered as "the most miserable specimens of humanity that can be found in the western hemisphere." Mr. Brydges, however, who has lived among them for nearly a quarter of a century, says they are not

so degraded as they have been represented—not so black as they have been painted—and they are greatly improved in their condition since he went to live among them. The charge which has been made against them, that they are cannibals, he assures us is emphatically untrue. “Cannibalism is utterly impossible among them, for the reason,” as he says, “that they look upon human life as sacred,” and from this circumstance the friends of every person assassinated or killed believe that they are in honor bound to avenge his death. They do not eat meat which is not cooked. They do not marry with blood relatives, however remote. Some of the men have one wife; some have two or three; but they never marry first or second cousins, or near relatives, as something abominable. On the other hand they are very immoral and lax in their conduct and conversation, and their continual offenses against each other keep their communities in a chronic state of inquietude and violence. There are very few of them whose bodies do not present scars and wounds, and deaths frequently occur from their personal wrangles. They are quarrelsome and irritable, and in their dispositions they are both crafty and treacherous. Having no fixed principles, they are governed entirely by their desires and passions. Tattooing is unknown, but the girls paint their faces for fashion and the men for mourning. They are fond of each others’ company, and sitting around the fires of their huts or wigwams, they are very jovial over their meals. When they have satisfied their hunger in the amplest manner—for they generally have an abundance of food—they indulge in the most animated conversation and in the most excessive demonstrations of joy. Their laughter is natural and hearty, but it is sometimes so excessive and boisterous as to drive a serious person quite frantic.

The Yahgans formerly numbered about 3,000 souls, but small-pox and other epidemics have of late years been very fatal among them, and their numbers are now considerably reduced. They live usually in groups or villages of twenty or thirty families. They are not of a uniform type. While some are quite stalwart, others are exceedingly diminutive. Some have straight hair; others have it curled and crispy. Their principal food

consists of mollusks, fish, sea-calves, birds, strawberries, etc. They manufacture fishing nets from tendons, with a mesh quite identical with those manufactured from hemp in the United States. They seem to understand the division of labor. The women cook, fish, and paddle the canoes, while the men hunt, make and repair the canoes, and collect fuel. The women are exceedingly expert with the canoes, and are much more fearless swimmers than the men. They paddle along the coasts for hundreds of miles in their canoes. The principle of women's rights is so far respected that the wife disposes, as she wishes, of whatever fish she may catch over and above what is required for her wigwam. They fully understand the art of cooking, though in rather a primitive way. On this subject Mr. Brydges says:

These Fuegians are well acquainted with the various uses of fire, and cook their fish, birds, meat, and eggs in different ways, but until I went to live among them they never boiled them in water, simply because they had no vessels in which they could do so. They toasted whale or seal blubber on pointed sticks stuck in the ground, and caught the oil in large mussel-shells placed underneath. As these filled they poured the oil into bladders and pipes for future use. Fish-fat they put into large shells and caused the oil to flow from it by placing heated shells upon it. When they wished to cook birds whole they placed them on the burned-out embers and filled them inside with heated stones. They baked their eggs by breaking a small hole in one end and placing them upright in the embers before the fire, turning them around from time to time to make them cook equally. They uniformly used the blood of animals, but always in a cooked state. I have never seen or heard of the Yahgans eating any kind of meat or fish raw, excepting certain kinds of limpets, which they much prefer in an uncooked state. Although until I came they had no vessels in which to heat water on the fire, I have heard occasionally of their having heated water by dropping heated stones in it as it stood in bark or wooden buckets. While they do not cook their vegetable food, they thaw and slightly warm, in winter, the frozen tree parasitic fungi before eating them.

Mr. Brydges gives many more interesting details than those which I have quoted or condensed above in reference to these people. But the most remarkable one is his statement that the language of the Yahgans is "soft, rich, and very full;" how rich and how full may be inferred from his almost incredible an-

nouncement that he has accumulated a dictionary or vocabulary of no less than thirty thousand words of the dialect spoken by the Indians in those distant regions. Lieutenant Bové, who probably got his information in regard to the language of the Yahgans from Mr. Brydges, makes a similar statement, and in his narrative adds that "the words are sweet, pleasant, and full of vowels." As they neither read nor wrote in their primitive condition, one might be disposed to ask what in the world is the use to them of so many words, since among such an uncivilized people a few hundred would seem to be sufficient for the limited number of their ideas, or the limited purposes of life to which they could apply them. But it may be that their language is all that is left to them of a former civilization.* Mr. Brydges states

*In the *Nineteenth Century* for January, 1885, will be found an article on the Fuegians by the great scientist, Max Müller, in which he writes as follows in regard to the remarkable language of that people:

"Nothing can be more interesting than the study of races who have no literature, but whose former history may be read in their languages and their tools, and whose present state of civilization or savagery may certainly be used to throw collateral light on many phases in the history of more highly civilized nations. Only let us remember that these races and their languages are as old as the most civilized races and their languages, while their history, if we may so call it, seldom carries us back beyond the mere surface of the day. If we in England are old the Fuegians are not a day younger.

"But while scientific anthropologists have long given up the idea that if we want to know the condition of primitive man we must study it among the Fuegians, the subject has lost none of its charms. The first question which we have to ask when we have to speak of savages is whether there is any indication of their having once reached a higher stage from which they have descended. Most people would naturally think of Fuegians and Hottentots as retrogressive or decaying savages, because they are dying out wherever they are brought in contact with European civilization. But we must be careful before we deny the recuperative power even of retrogressive savages, and must look for some evidence beyond mere statistics.

"As I look upon language as a work of human art, I must confess that nothing has surprised me so much as the high art displayed in the languages of so-called savages. I know quite well that a great abundance of grammatical forms, such as we find in these savage dialects, is by no means a proof of high intellectual development. But if we consider how small is the number of words and ideas in the ordinary vocabulary of an English peasant, and if we find that one dialect of the Fuegian, the Yahgan, consists of about 30,000 words (as Giacomo Bové states in his *Travels*, 1881), we certainly hesitate before venturing to classify the possessors of so vast an inherited wealth as the descendants of poor savages, more savage than themselves. Such facts cannot be argued away or ignored in our estimate of the antecedents of the Fuegian race.

"I select the Fuegians as a crucial test simply because Darwin selected them as the strongest proof of his own theory, and placed them almost below the level reached by the most intelligent animals. When Darwin looked at the Fuegians he no doubt saw what he tells us, but then he saw it with Darwinian eyes; he says: 'Viewing such men one can hardly believe that they are fellow-creatures and inhabitants of the same world. Their language scarcely deserves to be called articulate—a mixture of hoarse, guttural, and clicking sounds.'

"With regard to their physical aspect Darwin must have been either very unlucky in the Fuegians whom he met, or he cannot have kept himself quite free from prejudice. Captain Parker Snow, in his *Cruise of Tierra del Fuego* (London, 1857), speaks of them as really beautiful representatives of the human race. Professor Virchow, when exhibiting

that he now speaks the dialect of these people with the same facility that he speaks the English language.

During the many years, however, that Mr. Brydges has been among these Indians very great changes have taken place in their social and intellectual status. Mr. Darwin himself would scarcely recognize them as the same people. Those who have, during the last twenty-five years, come in contact with Mr. Brydges, and by him been brought into relations with the South American Missionary Society of London, are no longer "the abject specimens of humanity" that Darwin described. Mr. Brydges assures us that some of them are now quite civilized; that "they have learned to read and write, and above all fear God and keep His commandments." His place of residence is at Ushvia, on the north shore of Beagle Channel, where he has a wife and six children, and where his missionary labors for all these years have been active and continuous. He says of himself:*

I have never been alone among the natives, as there have always been associated with me one or more fellow-workers with their families. Our life among the Yahgans has been eminently practical, with the view of

a number of Fuegians at Berlin, strongly protested against considering them as an inferior race or a connecting link between ape and man. And as for Darwin's estimate of their language, I doubt whether, so far as sound is concerned, any one would consider Fuegian as inferior to English. Lieutenant Bové, speaking of the Yahgan dialect, says, 'the words are sweet, pleasant, and full of vowels,' but he admits that some of the other dialects are harsher.

"Even if their language was as guttural as some of the Swiss dialects, how shall we account for the wealth of their vocabulary? Every concept embodied in their language is the result of hard intellectual labor, and although excessive wealth may be an embarrassment, there remains enough to prove a past very different from the present. The workman must have been as great as his work; and if the ruins of Central America tell us of architects greater than any that country could produce at present, the magnificent ruins in the dialects of Fuegians or Mohawks tell us of mental builders whom no one could match at present.

"The Duke of Argyll, in examining the principal races commonly called savage, points out that degraded races generally inhabit extreme ends of the continents, or countries almost unfit for human habitation. He concludes that they did not go there of their own free will, but that they represent conquered races, exiles, or criminals. He considers that the Fuegians probably came from the north; that their ancestors may have participated in the early civilization of Chili, Peru, Brazil, or Mexico; and that the wretchedness of their present home fully accounts for their degradation.

"Wherever we look we can see the rise and fall of the human race. We can see it with our own eyes in some of our oldest and noblest families. We can read it in history if we compare ancient with modern Greece. The idea that the Fuegian was salted and preserved for us during many thousands of years, so that we might study in him the original type of man, is nothing but a poetical sentiment, unsupported by fact, analogy, or reason. One thing is quite certain, that the private diary of the first man will never be discovered least of all at Cape Horn."

*Published in the Buenos Ayres *Standard*.

leading them to cultivate the soil, keep cattle, build permanent huts, and live in a more orderly and settled manner. I began to learn the native language in 1858, joined the mission service in 1861, and could converse freely with the Indians in 1863, when, in company with Bishop Sterling, I fixed my residence among them. The improvement which has taken place in their condition since is wonderful. They have now learned the arts of civilized life. They have acquired the skillful use of fire-arms and some of them are splendid sportsmen. They own guns and purchase ammunition. They are acquainted with the value and use of money, English or Argentine, a good sum of which is continually passing through their hands, as they prefer selling for money rather than bartering. They occasionally visit Sandy Point and the Falkland Islands, and are thus thrown in direct contact with a civilization which they are anxious to attain to. My object in coming to Buenos Ayres has been to obtain a grant of land in the Beagle Channel, on which to create a farm and employ native labor upon it, thus seeking to supply a want in reference to agricultural products, which we have long felt, and at the same time insure the well-being of some of the natives.

As may readily be supposed, the Argentine Congress, at its late session, was not long in deciding to donate to Mr. Brydges twenty-four square miles of land at Ushvia, fronting on Beagle Channel.

A very interesting fact, illustrating the labors of Mr. Brydges among the Yahgan Indians, is related by Mr. Lista. During his explorations he met a body of these natives on the eastern coast, and they addressed him in the English language!

Such is *Tierra del Fuego*,* or at least that part of it which belongs to the Argentine Republic; not altogether the miserable "tail end of creation" which some explorers in their ignorance have painted it, but a country diversified and picturesque in the extreme, with a beautiful alternation of mountain, upland, and plain, with immense forests of several varieties of valuable timber, with wide pampas and extended plains, with a variety of succulent grasses suitable for both cattle and sheep, with a large number of small rivers and water-courses running to the four points of the compass, with lakes and lagoons in different parts

*My report has special reference in great part to that portion of *Tierra del Fuego* which belongs to the Argentine Republic and lies along the Atlantic Ocean. Since its completion, however, Mr. Julius Scheltze, a mining engineer, who has just returned from an extended survey of the western parts of the Fuegian archipelago, has furnished me with a very interesting letter on the characteristics of that portion of the Magellan land.

of the interior, with a large number of beautiful bays and harbors, with various kinds of wild animals valuable for their flesh and their furs, with an abundance of excellent game, with a climate somewhat rigorous in the winter, but healthful in the extreme and suitable for the cultivation of the cereals and nearly all varieties of vegetables; a country, indeed, which is capable of wonderful development and possessing quite all the elements necessary for sustaining a large population. There is no country which has been so persistently maligned and misrepresented, and simply because those who visited its coasts never penetrated into its interior, but drew their conclusions from what they saw, or imagined they saw, from their ships.

Fortunately, the explorations which have been made during the last year or two have quite lifted the veil from the fastnesses of the interior, and revealed—though only partially as yet—what has heretofore been so densely shrouded in mystery and gloom. Mr. Popper, who, as I have said, has just finished an exploration entirely across the country, from Useless Bay on the west to San-Sebastian Bay on the Atlantic, in an interesting diary of his travels,* speaks of the future which is in store for the gold mines in the region of the Sierra Balmiceda, and of the "beautiful plains" and "good pasture lands" which he found on the Argentine side of the island. While on the Cullen River he found himself in the midst of "an elevated plain covered with grass, well fitted for sheep, with not a single bush to be seen on the horizon." Of the forests in the mountain region, he says:

At every step the vegetation became more and more rank and luxuriant, increasing in height and density until we were obliged to come to a standstill. Before us was the forest like a solid wall. Without any kind of outlet or opening it surrounded us on all sides, so that at certain times we could neither advance nor go back. It was a gloomy forest. The ground was covered with the rooted up and fallen trunks of trees, and masses of humid and decomposing vegetable matter.

On reaching the heights of Sierra Balmiceda through a series of almost insurmountable obstacles, he says:

The splendid panorama spread out before us, and of which these

*Just published in the *Southern Cross* of Buenos Ayres. His report is not yet printed.

heights commanded a view, fully recompensed us for our labor. Towards the west, opening like a geographical map, appeared Cape Monmouth, with its lagunas forming icicles of most fantastic shapes, and the Straits of Magellan, whose vaporous atmosphere scarcely allowed a glimpse of the continental coast; to the southwest was the island of Dawson with its dense evergreen forests; towards the south was the White Mountain range, overlooking the Beagle Channel; and far away, breaking off in the horizon, were the mountains of Sarmiento and Darwin, which, like gigantic sentinels of the Atlantic, raise their heads, covered with eternal snows, far beyond the region of tempests.

Of the wild game of the country he speaks in most rapturous terms. I again quote from his diary:

We are on the banks of the river Beta. We remark a fire made by the Indians two leagues to the westward. The valley crossed by the stream produces some bramble bushes of the *Berberis oxifolia*, and offers excellent pasture. We are surprised at the abundance of game. At about four kilometers from the mouth we start up a guanaco, which our dogs have no difficulty in catching. As we approach our encampment we scare up a covey of the *Chloefaga megellanica* with its young searching for worms in the grass; there go a pair of ducks (*Anas cristata*) gliding along the limpid surface of the stream and followed by a new generation of their own species. On all sides there are flocks of birds of all sizes and colors. On descending the valley we remark great animation among its inhabitants. A multitude of ducks and other birds arise with a sharp scream and incessant flapping of the wings. They fly in circles over our heads, and sometimes they come so near us that they touch our caps with the tips of their wings. In the meantime we are occupied in catching young pigeons as they try to hide themselves in the burrows. We pick up eighteen pigeons, while *la canardière* secures three geese and eight ducks, etc.

Mr. Ramon Lista is even more emphatic in his estimate of the Argentine portion of Tierra del Fuego. From his report to the Government, now just published,* I translate as follows:

I have traveled from one extremity of the country to the other, and I am scarcely able to give entire credit to all that my astonished eyes have seen. I expected to find a cold and chaotic island, a barren rock, "the ruin of a former world," as Captain Wallis has called it. Instead of this, I have bivouacked continuously on a flowery plain of grasses capable of sustaining thousands of cattle and sheep. I have discovered leagues upon leagues of rich valleys, accessible mountains almost without snow,

*"Viaje al Pais de los Onas, Tierra del Fuego, par Ramon Lista, miembro de la Aca. demia de Ciencias, etc. Buenos Ayres, 1887." Pp. 39 and 40.

and magnificent forests where fern trees and other plants are found, which in Buenos Ayres are not able to live, except under the shelter of a greenhouse.

I have traveled much; I have seen the forests and cataracts of the northern Misiones; I have crossed the pampas from Carhué to Choyque-Mahuida, and I have explored almost all of Patagonia; but nowhere have I experienced such profound emotions from the contemplation of natural scenery as in Tierra del Fuego. The sublime landscapes—almost tropical—of its evergreen forests, the mildness of its climate, and the rich pasturage of its virgin prairies completely refute the stories which in all ages and among all peoples have been circulated by its calumniators. As all the great navigators who have explored its coasts—Magellan, Sarmiento, Cook, Byron, King, Fitzroy, and others, ancient and modern—have painted Tierra del Fuego in the most somber colors, perhaps my words may seem bold and insolent, or the offspring of a prejudiced enthusiasm; but then the interior of the island, which I have had the fortune to explore, was entirely veiled to all those illustrious navigators.

The appearance of this *terra incognita* is most beautiful; something like that of Norway, and not a little like that of Switzerland; and if it is not an Eden or an Eldorado, it is none the less rich and fertile. In its grassy valleys and in its dense and wide-extended thickets of juicy shrubs and plants we can see a revelation of its future pastoral riches. Its marine climate is tempered by the winds which blow from the north during the winter; and when up the tortuous valleys of verdant grasses the traveler reaches the boundary of the great forests, he cannot fail to enter his protest against the calumnious epithets which during all these years have been directed against a country in whose solitudes live thousands of human beings, fed and clothed entirely by the prodigality of nature.

I could translate from Mr. Lista's report many more pages in the same strain of appreciation of the Argentine portion of Tierra del Fuego, but this is sufficient to convince any one that in spite of the maledictions which have from time immemorial been persistently heaped upon the country, there are large portions of it on the Atlantic side which must ultimately attract the attention of the civilized world, not merely for the mineral wealth which it contains, but likewise for the pastoral industry which it could support.

Certainly, however, the fates have as yet not been propitious to Tierra del Fuego. Thus far there has not been any develop-

ment of that far southern land by way of colonization or settlement. It is still in almost the same state of unsubdued nature that Magellan found it.

The only existing settlement anywhere in the vicinity of Tierra del Fuego is on the northern side of the Straits of Magellan, at Sandy Point (Punta Arenas), whose geographical position is important, whose climate is genial, and whose commerce and industries, already considerable, have great future promise. The place was founded in 1843 by the Chilian Government as a convict colony or penal station. It is in charge of a governor and other proper officials, who hold their appointment from the Chilian Government. A few years ago the convicts overpowered their guards and escaped, destroying a large part of the town. They then made their way through Patagonia to Chupat, on the Atlantic coast, where they were captured, brought to Buenos Ayres, and afterwards returned to Chili. Since then, I believe, that Government no longer uses the place as a station for its convicts. To-day the town numbers about 2,000 inhabitants, belonging to all nationalities. It forms a central point for furnishing supplies for the vessels which annually sail on the southern coasts of Tierra del Fuego in search of seals and guano, as also for the gold miners who are at work on either side of the straits. It likewise furnishes a market as well as nucleus for the pastoral interests, which now have attained to considerable proportions along the northern shores of the Straits of Magellan. It is estimated that there are already two hundred thousand sheep between the Gallegos River and Sandy Point, the pasturage being of a very good quality. Two lines of steamers, one the German Lloyds and the other the Liverpool and Pacific line, now make regular semi-monthly trips through the straits, touching at Sandy Point on their passage each way. It is also becoming quite a coaling station for war and other steamers, coal of a very fine quality having been found in the vicinity. This coal is also, to some extent, now sold in Buenos Ayres. Cargoes of beech timber are also finding their way to this market. The port has a fine anchorage and a convenient mole for the shipping. The mixed population, in its love of conviv-

iality and amusements, in its propensity to gamble, and in its carelessness of the future, quite reminds one of the very early days of our own San Francisco.

In Tierra del Fuego the only point which can be called a settlement is Ushvia, the site of the missionary station of the Rev. Mr. Brydges. It consists now of several families, teachers, etc., connected with the mission. For that purpose several houses have already been erected, and several more are in process of construction. The embryo town is on a beautiful bay, looking off towards the somber forests of Novarino. In the rear it is protected by forests which line the mountain sides. The shores are gently sloping and covered with a rich carpet of grass. At different points beautiful streams pour down the slopes, sometimes forming cascades and sometimes leaping over high precipices. In this charming location the English mission has, for the last twenty-five years, been furnishing food and clothing and religious instruction to hundreds and hundreds of native Indians. Already a large clearing has been made in the forests, and the place now not only has its vegetable-gardens and orchards, but handsome pleasure-grounds, where bloom myrtle, and fuchsias, and magnolias, and violets, etc., with many choice varieties of plants and shrubs.

In 1884 the Argentine Government organized the Territory of Tierra del Fuego, "bounded on the north by the Straits of Magellan, on the east by the Atlantic Ocean, on the south by the Atlantic Ocean, and on the west by the Chilean boundary under the treaty of 1881, and including States Island," and the capital of the territory has been fixed at Ushvia, but occupying the opposite side of the bay. Several buildings for the use of the governor and his officers have already been erected, as also barracks for the quarters of a military guard. One or two Argentine men-of-war are nearly always at anchor in the bay.*

Besides this there are a few settlements in Future and Use-

* Mr. Lista suggests that the capital or "prefectura" of Tierra del Fuego be removed by the Argentine Government from Ushvia to the Bay of Good Success, which offers both shelter and a good anchorage for vessels, while it is only seven miles distant from Cape San Diego, and twenty miles from States Island. It would thus afford great service to the hundreds of vessels of all flags which annually pass through the Straits of Lemaire. The change will probably be made and a light-house erected there.

less Bays, the quarters of the gold miners who are working there, and on the river Santa Maria and other streams which come down from the mountains.

Some years ago, Mr. Steubenrauch, the British consul at Sandy Point, attracted by the beautiful plains of Gente Grande Bay, resolved to establish a sheep farm there; and he has not only built some houses, but has reclaimed a large *estancia* with wire fences, and stocked it with sheep brought from the Falkland Islands, placing a missionary from those inslands in charge of the place. At last accounts it was progressing favorably.

A number of miners have been arranging to go to San Sebastian Bay in the prospect of being able to find gold in paying quantities near that point.

On States Island there are a number of perfectly sheltered bays, and there is now the nucleus of a settlement there, a light having been erected fronting on the Straits of Lemaire.

In concluding this report it is gratifying to be able to state that there is a prospect of a brighter future in store for Tierra del Fuego. The narratives of Mr. Lista and Mr. Popper, and the statements of Mr. Brydges, have brought that country to the front in so favorable a light that the Argentine Government is determined to make a movement at once for its colonization and development. To this end Governor Paz, the recently appointed governor of Tierra del Fuego, is now in this city arranging for a thorough exploration of the most available points for settlement, and will direct his attention not merely to an investigation of the mineral resources of the country, but to an examination of the pasture lands with a view to opening cattle and sheep *estancias* there. A full corps of competent men will accompany him and assist him in his labors. The Argentine national steamer Magellanes, loaded with supplies and the necessary outfit, will sail in a few days from this port with the expedition on board, and the work is expected to commence so soon as the spring opens. I have every reason to believe that it will be the date of a new departure for that hitherto unknown, and much misrepresented portion of South America.

CURRENT NOTES.

THE SMITHSONIAN INSTITUTION.—We note with pleasure that Professor S. P. Langley has been appointed Secretary of the Smithsonian Institution in the place of Professor S. F. Baird, now deceased. Professor Langley had been an assistant secretary for some time.

THE REVUE COLONIALE INTERNATIONALE.—We regret to learn that this excellent monthly review of colonial affairs is likely to cease to appear because of insufficient support. It is a very valuable publication, and should find a large reading public among those interested in geography, meteorology and political science, not to speak of those more directly interested in colonial matters.

ADDITIONAL STUDIES OF THE SUNSET GLOWS.—In the fine second volume (which in order of publication precedes the first) of the observatory at Nice, M. Thollon and M. Perrotin give some results of their study of these phenomena. They were favored by the pure air at Nice, and seemed to have observed Bishop's ring at a very early date. They definitively conclude that the phenomena were due to the eruption in the Straits of Sunda. In the same volume are some interesting notes on the terrestrial lines in the solar spectrum, spectroscopic studies of recent comets, and a good map resulting from M. Thollon's studies of Mars.

DR. HANN'S METEOROLOGICAL ATLAS.—These twelve maps with accompanying text, are of elegant workmanship, both from the scientific and technical point of view. They are crowded with information according to the latest results of observation and exploration. The twelve sheets contain 61 different maps, and yet everything is so arranged that the facts detailed can be seen at a glance, and there is no confusion. The maps are finely colored, and some novel but very suitable projections are used. More detailed attention is given to the United States than is

usual in European atlases. We can commend this atlas to every meteorologist; it is in fact indispensable to them all. The atlas can be obtained separately, but it is part IV. of Berghaus' *Physicalischer Atlas*. If the rest is as perfect as the atlas of meteorology it will form a very valuable addition to any library.

THE CONSTELLATIONS.—There is one sort of astronomical work that meteorological observers can follow with ease to themselves and advantage to science, and that is the observation of meteors. To make the observations of value, however, these must give the exact time, and also, as exactly as possible, the path of the meteor. For the latter a knowledge of the constellations is necessary, and we write this note to call attention to a plain and easy guide to this knowledge, an adaptation of which to the use of American students has recently been published. We refer to Mr. Proctor's "Half-hours with the Stars," published by Putnam's Sons. It is not expensive, and it is so happily arranged that the use of it is very simple.

Another good means of getting this knowledge is afforded by Whitall's movable planisphere. This is a very handy piece of apparatus, adaptable to a great variety of problems, such as the appearance of the heavens at any hour in the year, the rising and setting of heavenly bodies, etc. It has a great many uses, but requires some practice to use it to the best advantage.

REDUCTION OF WIND OBSERVATIONS.—One of the oft recurrent problems of the meteorologist, is that of deducing the prevailing wind from a large number of observations. The Traverse Table, as used by navigators, and given in many sets of tables, as in Loomis' trigonometry, has heretofore afforded the simplest method of procedure, but in the December number of the *American Journal of Science*, Professor H. A. Hazen has given a table with instructions, which renders the work still easier. The method once mastered, these short tables would render the work very expeditious. It is expressly stated that the tables are for the use of voluntary observers, and for that reason probably nearly all terms unintelligible to those who have never studied

trigonometry, are omitted. A set form is given, and any one who enters the observed wind directions on this form can obtain the mean direction if he is only acquainted with simple arithmetical methods. To one who seeks a reason for what he does, however, the explanations are not entirely free from ambiguity. For instance, on page 462, near the bottom, it is not easy to see why the tabular value 19° must in that case be subtracted from 90° . We should say that it was, not because the denominator is less than the numerator, but rather because, for reasons depending on the tabular arrangement, we have inverted the fraction and got the cotangent instead of the tangent, that is W. 19° N., which is equivalent to N. 71° W.

THE NEW HONDURAS.—We can commend this book as a contribution to a much neglected subject. The literature on Honduras is sparse, and for the most part quite old. "The New Honduras," by Mr. Thomas R. Lombard, assisted by Floyd B. Wilson Esq., and others, and published by the Brentanos, gives fresh and reliable information derived from actual observation. It is pleasantly written and well illustrated; and that it is written in the interests of mines in the western part of that State, detracts in no way from the value of the information it imparts. From the same circumstance it arises naturally that more attention is given to the western part of the country. Comparisons when made are generally unfavorable to the North Coast,—not always with entire justice, as we think. The book which shall do justice to the present condition of the East Coast of Central America remains yet to be written. It is the country of the cocoa-nut and banana, of the mahogany tree and rose-wood, a country of admirable climate, generally very healthful, and of extraordinary resources.

INSTRUCTIONS TO VOLUNTARY OBSERVERS.—The Signal Office has recently published as an appendix to its Annual Report for 1886, a revision of the Instructions to Voluntary Observers. This is especially timely in consequence of the large extension of the State weather system of voluntary observers, and the

resulting necessity for a hand-book, giving all needful information relative to instruments, their exposure, and the conduct of observations. The old edition gave a very scanty treatment of many subjects of prime importance, and contained in their place considerable unpractical and irrelevant matter. In the present edition this is reversed. The description of Joule's apparatus for temperature is wisely omitted, and new paragraphs embody the recent progress made by the workers in the Signal Office, in thermometry and hygrometry. This progress embraces all the elements of observational precision—instrumental accuracy, character of exposure and methods of observing. In hygrometry, also, the book contains the new Signal Service dew point and humidity tables. These are computed from a formula, developed by Prof. Ferrel, from a large amount of new and accurate experimental data, and owe their excellent arrangement to Professor Hazen. They are undoubtedly superior to the humidity tables heretofore in use in this country.

Under *precipitation* the instructions have been condensed, and thus the essential features are made more prominent. It would seem, however, that the *exposure* of the rain gauge is much too scantily treated in the single sentence that is given it. Perhaps this is because the Signal Service rain gauge exposures are themselves so bad.

The revision of the remainder of the instructions seems for some reason to have been suspended—not, however, because they do not need it. The paragraph on the wind vane repeats the time-worn statement, that "as a flat vane is always in a neutral line, an *accurate* and sensitive one is made by fastening two plates together, forming a wedge." This is a very inadequate and misleading presentation of the case. The straight vane is not *always* in a neutral line, for it is out of the neutral line at every shift of the wind, and if it were "always in a neutral line," that is, in the line of the wind, it would thereby certainly be "accurate." Again, if the sentence intends to imply, as it seems to, that a straight vane can not be "sensitive," it is a palpable error, for sensitiveness depends *primarily* upon the amount of friction on the bearings. The true relation is as follows: Other

things being equal, the wedge-shaped vane is slightly more sensitive, but its principal advantage lies in its greater stability.

The statement is also repeated under anemometer that "it has been proven, both by theory and experiment, that the center of Robinson's cups revolve with one-third of the wind's velocity." If anything has been proven by the work of Stow, Dohrandt, Thiesen, and Robinson himself, it is, that *in general* no such relation exists, although for some particular patterns this ratio may approximately hold good.

The formulæ, although few in number, are unfortunately not free from typographical error. In its general aspect, being printed in unleaded brevier type, the book has a decidedly uninviting appearance, and is in this respect much inferior to the old edition. There would seem to be no good reason why the Signal Office should not get its printing done in just as good a form as other bureaus, unless it be that, in this as in other matters, the rules of the War Department hamper and interfere with its work.

G. E. C.

THE INTERNATIONAL CHARTS AND SUMMARIES.—As issued by the Signal Service these charts and summaries are in an attractive and convenient form. For the month of September, 1886, only the pamphlet summary and review with two charts was issued, but for October, we have in addition to that a chart of isobars and winds for each day of the month. The charts are large and include the entire extra tropical part of the northern hemisphere. The projection is polar, which is for this purpose much more instructive than the ordinary projections would be, the time selected for the map, or Greenwich mean noon, at which instant of absolute time simultaneous observations are taken at all the stations. The stations made use of are upwards of 400, in addition to which more than 300 masters of vessels report their observations, thus enabling the maker of the chart to extend his lines, not only over the land, but over the Atlantic ocean as well. The barometer reading is reduced to sea-level, and by a gravity correction to latitude 45° , and the isobars on the charts are drawn for each two-tenths of an inch. The wind is also

entered on the map, the direction being indicated by an arrow and the velocity by its feathering.

The "Summary and Review" is an eight page pamphlet, resembling the "Monthly Weather Review" in size and appearance. In it are given the means of the ordinary meteorological elements in both centesimal and British standards. The ship reports are condensed into a series of deduced averages for certain selected positions, which are symmetrically arranged. Following these is a review of the international weather for the month, and an account of the different areas of low pressure which have been observed. Appended is a chart of mean elements and one of storm-paths.

The prominent part taken by the Signal Service in international observations is fully sustained by these publications. They are highly creditable in every way. The amount of labor involved in the preparation of them must be very great, and we note that General Greeley says that his force is insufficient for carrying out all the details as he had wished. In an undertaking which is so praiseworthy from every point of view there should be no question as to sufficient assistance, and if additional appropriations are necessary, they should be given.

"UEBER DIE TEMPERATUR VON PRAG." By Dr. Stanislaus Kostlivy. (Abhandlungen der Königlichen Böhmischen Gesell. d. Wissensch. VII. Folge II. Band). Prag., 1887, pp. 32.

Dr. Kostlivy, the well-known "adjunct" of the Vienna observatory for meteorology and earth's magnetism, has given us in this paper an excellent example of the results of an investigation of a special climatological problem. The mean yearly temperature of Prague had been previously deduced by Fritsch in 1850, in which he used the observations from 1771-1846. He obtained the value 9.58° C. Jalieick in 1851 found the value to be 9.95° C. from 8-9 years' observations. Kreil used the observations from 1771-1859, and received 9.50° C. as the result. In the volume of the K. K. Cent. Aust. für Met. u. Erdmag., 1869, the normal mean for 20 years (1848-1867), is found to be 9.29° C. Augustin found for the 40 years (1840-1879), mean 9.16° C.,

and for 80 years a mean value of 9.35° C. Before undertaking a new computation, Dr. Kostlivy went carefully over all available sources of information on the subject. He found for example that before 1871 no correction had been applied to the readings of the observing thermometer, but after 1871 its correction as determined then was applied. Dr. Kostlivy devotes several pages to a discussion of the thermometer correction, and gives several tables of comparisons with various standards throughout the required range of temperatures. (Such tables are instructive to the meteorological observer in showing the accuracy attained in the construction of good thermometers.)

For a mean temperature of Prague for the period 1851-1885, Dr. Kostlivy finds the value to be 8.83° C., by using the hourly means, but if tridaily observations are used [$\frac{1}{3}(6+2+10)$] the mean is 8.73° C. Reducing the value 8.83° C. to sea level, and there results 9.84° C., which different exposures in the city might change by 3° - 4° .

Then follows a discussion of the monthly oscillation of temperature for the hours 6-2-10, and mean. The yearly march of the temperature is given for ten day periods; and the mean temperature is expressed by the Lambert-Bessel formula. The general results are also compared with those of other stations.

In appendices I.-IV. are given the mean air temperature for 6-2-10 for each month of the 35 years (1851-1885) in conveniently arranged tables, and the 24-hour mean for each month of the same period. From this last table we find that the lowest annual mean was 7.09° C. in 1864, and the highest was 10.49° C. in 1868.

F. W.

ROYAL METEOROLOGICAL SOCIETY.—The usual monthly meeting of this society was held on Wednesday evening, December 21, at the Institution of Civil Engineers, 25 Great George Street, Westminster; Mr. W. Ellis, F. R. A. S., President, in the chair.

The Rev. R. Barker, Mr. W. W. Day, M. D., Mr. H. N. Dickson, Mr. H. Harries, Mr. P. F. Jeffrey, B. A., Mr. H. A. Johnston, and Mr. J. Wolstenholme, were elected Fellows of the Society.

The following papers were read:

(1) "The Mean Temperature of the Air at Greenwich, from September, 1811, to June, 1856," by Mr. H. S. Eaton, M. A., F. R. Met. Soc. This is a discussion of the Meteorological Journals of the late Mr. J. H. Belville, and those of the Royal Observatory. The general results of this investigation are: 1. That there was no appreciable change in the mean annual temperature of the air at Greenwich in the period 1812 to 1855, inclusive. 2. That on the eminence on which the Royal Observatory is situated the average temperature at night, or rather the early morning, is in all cases higher than over the lower grounds. 3. That with a north wall, or possibly a north window exposure, higher maximum temperatures are found at the lower stations. 4. That the movements of the thermometer are retarded with a north-wall exposure as compared with an instrument on an open stand, especially where the situation is a confined one, the indications of the thermometer not following changes of temperature so promptly, owing to the modifying influence of the adjacent building.

(2) "Report on the Phenological Observations for the year 1887," by the Rev. T. A. Preston, M. A., F. R. Met. Soc. The past season was a most exceptional one. For flowers it was disastrous; fruit was generally a failure, though there were exceptions; those kinds which promised well turned out very small or spoiled by insects. Vegetables were universally poor; roots were destroyed by insects or drought, and green crops soon passed off. The wheat crop, however, was better than was expected. Barley on light lands was poor, but that which was sown early was satisfactory. Meadow hay was not up to an average crop, but clover and seed hay were much more nearly so. In Kent the fruit crops turned out lighter than usual, but the prices have ruled higher.

(3) "Earth Tremors and the Wind," by Prof. John Milne, F. R. S., F. G. S. The author has made a detailed examination of the tremor records obtained in Tokio, and compared them with the tri-daily weather maps issued by the Imperial Government of Japan. From this comparison the following conclusions have been drawn: 1. Earth tremors are more frequent

with a low barometer than with a high barometer. 2. With a high barometric gradient tremors are almost always observed, but when the gradient is small it is seldom that tremors are visible. 3. The stronger the wind the more likely it is that tremors should be observed. 4. When there has been a strong wind and no tremors, the wind has usually been local, of short duration, or else blowing inland from the ocean. 5. When there has been little or no wind in Tokio, and yet tremors have been observed, in most cases there has been a strong wind in other parts of Central Japan. 6. From 75 to 80 per cent. of the tremors observed in Tokio may be accounted for on the supposition that they have been produced either by local or distant winds. 7. The only connection between earth tremors and earthquakes in Central Japan is that they are both more frequent about the same season.

(4) "Pressure and Temperature in Cyclones and Anti-Cyclones," by Prof. H. A. Hazen. The author has made a comparison of the observations at Burlington and on the summit of Mount Washington, U. S. A., and as the result of a study of about 4,000 observations from two days before till two days after the passage of cyclone and anti-cyclone-centres, he has arrived at the following conclusions: 1. In both cyclones and anti-cyclones the pressure lags from ten to eleven hours at the summit of Mount Washington. 2. The temperature change at the base precedes very slightly the pressure change, but at the summit the change occurs nearly twenty-four hours earlier. 3. The temperature appears to be a very little earlier at the summit than at the base, and certainly varies much more rapidly at the former. 4. In a cyclone, the difference in temperature between base and summit is less than the mean before the storm, but the difference rapidly increases after the centre has passed. Just the contrary is true in an anti-cyclone. 5. The total fall in pressure in a cyclone at the summit very nearly equals that at the base, and likewise the rise in an anti-cyclone. 6. The fluctuation of temperature, that is from the highest to the lowest, at the summit is double that at the base in a cyclone, but it is only a little greater in an anti-cyclone.



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